One and Two Neutron Transfer Reactions in Normal and Inverse Kinematics ◇

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1. Introduction

Single and two nucleon transfer reactions are very powerful tools for the study the structure of nuclei. Single-nucleon transfer reactions such as (p,d) and (d,t) enable the determination of excitation energy, single particle orbital angular momentum l or the total angular momentum J if polarization is used, as well as spectroscopic factors S.

A major thrust in nuclear structure physics is the study of short-lived nuclei far-off stability, so called exotic nuclei. Since no targets can be produced of such nuclei, they have to be used as radioactive beams, making reactions in inverse kinematics necessary. For such experiments proper targets are needed, such as deuterated PE foils for (d,p) reactions or tritium loaded Ti foils for (t,p) reactions.

We report here on test experiments for normal kinematics compared with inverse kinematics reactions at the Munich Tandem accelerator and at the HMI-Berlin.

2. Experiments

For the normal kinematics reactions the Munich Q3D spectrometer was used to measure excitation energies, angular distributions and analyzing powers. Fig. 1 shows differential cross-sections and analyzing powers for the ^{54}Fe($\vec{\mathrm{d}}$,p)^{55}Fe reaction with 14 MeV polarized deuterons in comparison with DWBA calculations using the code FRESCO [1]. Optical model parameters were taken from Ref. [3] with some empirical adjustment.

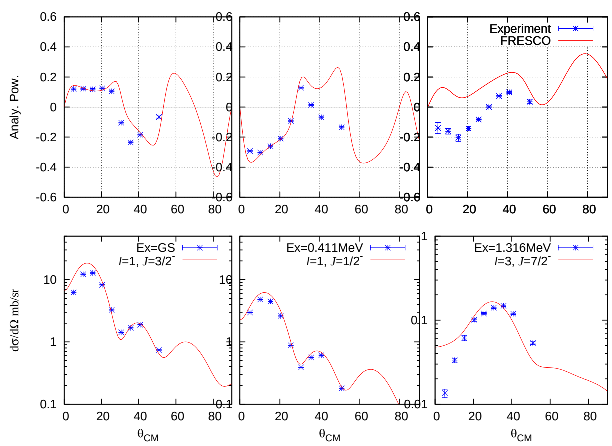

Fig. 1: Angular distribution and analyzing powers for the reaction ^{54}Fe($\vec{\mathrm{d}}$, p)^{55}Fe E_{d}=14 MeV for the ground state (left),0.411 MeV (middle) and 1.316 MeV (right) excited states compared with DWBA calculations using the code FRESCO.

The inverse kinematics for the previous reaction d(^{54}Fe,p)^{55}Fe were performed in the Q3D target chamber at incident beam energies of 2.5 MeV/u using a deuterated Ti foil of 500 $\mu g/cm^2$ thickness. A 300 μm thick annular Double Sided Silicon Strip Detector DSSSD, was used to detect the emitted protons from the transfer reaction. The detector covered θ_{lab} 130° → 159°, which corresponds to ≃ θ_{CM} 8° → 32° . Partial results are presented in Ref. [2].

The results have been compared with the DWBA calculations using optical model parameters used for the description of the normal kinematics reaction [3]. The good agreement between data and calculation shows that the inverse kinematics reaction can be well understood.

For two nucleons transfer reaction (t,p) the t(^{40}Ar,p)^{42}Ar experiment was chosen. A ^{40}Ar beam with an energy of 2.24 MeV/u was delivered by the HMI-Berlin ISL cyclotron. The target was 450μg/cm^2 thick tritium loaded titanium foil, with a ratio between titanium and tritium of 1:1.76. A similar DSSSD with thickness of 500 μm was used to detect the emitted protons from the reaction in similar angular range.

The angular distributions were extracted from the proton spectra and compared with one-step DWBA calculations using the coupled channel code CHUCK3 [4]. The optical-model parameters are taken from [5] with some empirical adjustments in order to account for the lower beam energy used in this experiment.

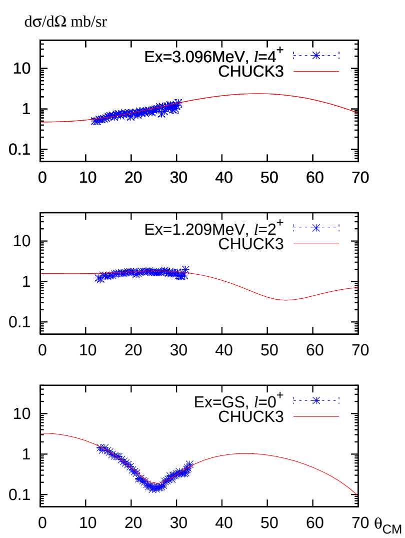

Fig. 2: Angular distribution for the reaction t(^{40}Ar,p)^{42}Ar $E_{^{40}\mathrm{Ar}}$=2.24 MeV/u for the ground state 0$^+$, 1.208 MeV 2$^+$ and 3.096 MeV 4$^+$ excited states.

References

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◇ Supported by DFG under project number KR2326/1-1